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PESTICIDE LEVELS, EGG AND EGGSHELL PARAMETERS OF GREAT HORNED OWLS[1]

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Abstract. Addled and viable Great Horned Owl eggs were compared in terms of pesticide levels egg and eggshell parameters. Addled eggs were generally larger in linear measurement and weight than viable eggs. Thickness index values for addled eggs were lower than those for viable eggs and for those previously reported by Osborne and Winters (1977) and Anderson and Hickey (1970). All egg samples analyzed for pesticide residues contained moderate amounts of DDE, PCB, dieldrin, heptochlor epoxide and oxychlordane, while some samples contained measurable amounts of HCB and TDE.

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During the past 20 years, numerous studies have reported residues of chlorinated insecticides in the eggs of wild birds, but few studies have concentrated on terrestrial strigiformes. Seidensticker and Reynolds (1971) analyzed eggs of Great Horned Owls (*Bubo virginanus*) and found measurable, but relatively low levels of DDT, DDD, DDE, and dieldrin in all eggs tested, plus heptochlor epoxide and PCB in some samples. Low levels of DDE were also reported in Canadian Great Horned Owl (Postupalsky 1970). In both raptors and passerines birds, parameters such as egg weight, volume, size, and shape have been related to geographical location, natural variation in egg sizes within clutches and species and to the widespread use of pesticides (Heath *et al* 1970, Osborne and Winters 1977). Anderson and Hickey (1970) showed that eggshell thickness was inversley proportional to residue levels in the egg. The purpose of the present study was to compare addled and viable eggs of Great Horned Owls in terms of pesiticide levels and eggshell parameters.

MATERIALS AND METHODS

Eighteen addled Great Horned Owl eggs representing 15 clutches were randomly collected in 3 Ohio counties (Butler, Delaware, and Hamilton) during 1974–77. Two viable eggs representing 2 clutches were collected in Delaware and Butler Counties in 1978. Addled eggs were collected in Ohio during raptor censusing by John B. Holt, Jr. and myself. After weights and linear measurements were taken, the eggs were frozen and stored at −5 °C for subsequent chemical analysis. Fertilization was determined by candling.

Egg and Eggshell Parameters. Fresh eggs were weighed to the nearest 0.01 g and compared to the weight calculated using the index of Romanoff and Romanoff (1949). Egg volume was measured to the nearest milliliter by water displacement and compared to the estimate obtained using the index of Kendeigh *et al* (1956). These index values allow one to compare our values with those reported by Osborne and Winters (1977).

A Starrett 1010-M dial micrometer was used to measure eggshell thickness (minus membranes). An average of 3 measurements, taken at the equator of the egg, was used as an index of shell thickness and compared with the thickness index as defined by Ratcliffe (1967, 1970) to determine relative eggshell thickness. This index has been used to document the relationship between eggshell thinning and the increase of persistent pesticides in the environment (Anderson and Hickey 1970, Cooke 1973).

Four addled eggs were randomly picked for a pesticide analysis conducted by the Ohio Department of Agriculture, Reynoldsburg, Ohio. Sample size was limited by financial considerations and technical assistance. Badly decomposed or dehydrated eggs were eliminated from the study. The contents of the eggs were prepared for chemical analysis by homogenization, divided into 25 g samples and analyzed by standard gas chromatographic techniques. The Organochlorine pesticides and polychlorinated biphenyls (PCB's) were separated on 2 ID glass columns and analyzed with a Hewlett Packard gas chromatograph. Column packing material in column one was 4% OV101 chromo-

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sorb W HP with 100–120 meshing, and for column two, a 1:1 ratio of 4% OV101 chromosorb W HP and 6% OV210 chromosorb W HP with 100–120 meshing. Eggs were analyzed for DDT, metabolities (DDE), dieldrin, oxychlorodane, heptochlor epoxide (Helptochlor), TDE, PCB AR 1254/60 (PCB's), hexachlorobenzine (HCB). Recovery ranged from 80 to 100% with an average recovery of better than 90%. A more detailed description of the analytical procedures are presented by Riechel (1977).

Data were statistically analyzed with Student's t-test, and chi-square tests. Since no statistical differences were found due to geographical variation, single egg samples per clutch versus multiple egg samples per clutch, or between different years, egg values were pooled for statistical analysis.

RESULTS AND DISCUSSION

Egg and Eggshell Parameters.

The fresh egg weights of 2 viable Great Horned Owl eggs ($\bar{X}=66.6$ g) was 2.5% lower than the estimated egg weight calculated by the weight index of Romanoff and Romanoff (1949) (table 1). The actual egg weights of addled eggs were not taken inasmuch as this measurement was considered an unreliable index because of dehydration, decomposition, etc. of the addled eggs. As determined by Romanoff and Romanoff's weight index, egg weights of eggs collected in 1975–1977 (n = 13) ranged between 3% and 9% higher in addled eggs, whereas in 1974 (n = 5) egg weights of addled eggs were 5% lower than the weights of viable eggs collected in 1977.

Addled eggs collected in 1975–1977 ranged between 1% and 6% longer than viable eggs while breadth of addled eggs was 2% larger than that of viable eggs. In 1974, length and breadth of addled eggs was 2% smaller than the length and breadth of viable eggs. These length and breadth measurements showed maximum variations of 7% and 3% respectively for eggs collected between 1975 and 1977.

The volume of addled eggs collected during the years 1975–1977 averaged 5% higher than that of viable eggs, whereas in 1974, the volume of addled eggs was 5% lower than that of viable eggs. Maximum variation in volume of addled eggs was 13% for eggs collected between 1975 and 1977. In comparing the combined average volume (addled plus viable) of this study with that reported by Osborne and Winters (1977), an increase in volume of 4% was found. These differences in egg volume could be attributed to biases in the formulas, but may also entail natural variation in egg size with clutches or species.

Shell thickness of addled eggs averaged 2% lower than that of viable eggs, and thickness index of addled eggs averaged 5% lower than that of viable eggs, 1% lower than that of New York GHO eggs (Osborne and Winters 1977), and 5% lower than that of Interior N.A. GHO

TABLE 1

Egg and eggshell characteristics of Great Horned Owl eggs.

Collect.	Egg Condition	No. Eggs	Length (mm)	Weight* (g)	Volume** (ml)	Thickness (mm)	Thickness+ Index
Springer							
1974	Addled	5	54.1±2	46.0±1	60.0±4	.354±0.04	1.87±0.02
1975	Addled	5	55.6±2	47.2±2	64.8±4	.361±0.02	1.93±0.02
1976	Addled	5	56.1±1	47.0±3	64.9±4	.360±0.03	1.94±0.02
1977	Addled	3	58.3±1	47.6±1	69.2±4	.365±0.04	1.90±0.03
1977	Viable	2	55.0±1	46.7±1	62.9±3	.367±0.04	2.00±0.03
Osborne and Winters							
1977++	Unknown	3	54.8	46.4	—	—	1.93±0.02
Anderson and Hickey							
1970++	Unknown	134	—	—	—	.366±0.03	2.03±0.03

*Weight Index (Romanoff and Romanoff 1946).
**Volume Index (Kendeight *et al* 1956).
+Thickness Index (Ratcliffe 1967).
++Eggs were collected prior to 1941, and were measured later. All values are mean ± S.D.

eggs (Anderson and Hickey 1970). These differences in thickness index values may be attributed to natural variations in eggshell thickness within the clutch or species, geographic variation, increased pesticide levels in addled verse viable eggs, and/or sample size.

Pesticide Analysis.

Egg samples analyzed for pesticide residues contained measurable amounts of DDE, PCB, dieldrin, heptochlor epoxide, and oxychlordane, whereas HCB and TDE were found in each of 2 samples (table 2).

In comparing pesticide data of my study with that reported by Seidensticker and Reynolds (1971), pesticide levels of DDE, dieldrin, and heptochlor epoxide were statistically higher ($P-0.05$) in this study. This finding follows the trend discovered in Red-tailed Hawks (Seidensticker and Reynolds 1971, Springer 1980) and other raptors, which is that addled eggs contain higher pesticide levels that viable eggs. Although Seidensticker and Reynolds (1971) reported only one sample analyzed for PCB (0.21 ppm), the average PCB levels of addled eggs in my study were 15 times higher than that of their viable egg value. Furthermore, since eggshell thickness has been shown to be inversely proportional to residue levels in the egg (Anderson and Hickey 1970), higher pesticide levels in addled eggs may have attributed to the decrease in eggshell thickness of addled eggs as compared with the eggshell thickness of viable eggs. In addition to the residues previously mentioned, I found low concentrations of HCB, TDE and oxychlordane. These differences may be attributed to regional use of specific pesticides and/or differences in habitat utilization by GHOs in differing geographical locations.

TABLE 2

Comparison of pesticide levels of Great Horned Owl eggs between Springer 1980 and Steidensticker and Reynolds 1971.

Chemical Residues	Springer, 1980		Seidensticker and Reynolds (1971)	
	Addled (n=4)		Viables (n=3)	
	Mean	Range	Mean	Range
DDE	3.0±1.6	0–4.3	0.7	0.4–1.1
Dieldrin*	1.7±0.4	.6–1.5	0.2	0.1–0.2
Heptochlor Epoxide	0.1±0.1	0–0.1	0.1	0.1–0.2
PCB (AR 1254/60)	3.1±1.4	1.5–4.4	0.2**	—
TDE	0.1±0.1	0–0.2	—	—
HCB	0.2±0.2	0–0.4	—	—
Oxychlordane	0.2±0.1	.1–0.3	—	—

*Since Aldrin is rapidly converted to dieldrin, the same figures will apply to these compounds (Prest and Ratcliffe 1970). All residues were measured as ppm net weight.

**Based on a single sample only.

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LITERATURE CITED

Anderson, D. W., J. J. Hickey 1970 Eggshell changes in certain North American birds. Proceed. 15th Intern. Ornith. Cong., Hague. 514–540.

Cooke, A. S. 1972 Shell thinning in avian eggs by environmental pollutants. Environ. Pollut. 4: 85–152.

Heath, R. E., J. W. Spann, J. F. Kreitzer, and C. Vance 1970 Effects of polychlorinated biphenyls in birds 15th Int. Orinithol. Cong., Hague. pp. 473–485.

Kendeigh, S. C., T. C. Kramer and F. Hammerstrom 1956 Variations in egg characteristics of the house wren. Auk. 73: 42–64.

Osborne, D. R., and R. Winters 1977 Pre-1941 eggshell characteristics of some birds. Ohio J. Sci. 77: 10–23.

Postupalsky, S. 1970 Effects of pesticides on populations of Bald Eagle and other fish-eating birds in the Lake Nipigon and Lake Superior region of Ontario: Report submitted to the Canadian Wildlife Service, Ottawa, Canada. 29 pp.

Prest, I., and D. A. Ratcliffe 1970 Effects of organochlorine insecticides on European bird-life. Proc. 15th Intern. Ornith. Cong., Hague. 486–513.

Ratcliffe, D. A. 1967 Decrease in eggshell weight in certain birds of prey. Nature 215: 208–210.

——— 1970 Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. J. Appl. Ecol. 7: 67–113.

Riechel, W. L. 1977 Putuxent Analytical Manual, Environmental Residues. Chemistry Project. U.S. Fish and Wildlife Serv., Putuxent Wildlife Res. Center, Laurel, Maryland 20811. 39 pp.

Romanoff, A. L. and A. J. Romanoff 1949 The Avian Egg. New York: Wiley and Sons. 918 pp.

Seidensticker, J. C., and H. V. Reynolds 1971 The nesting, reproductive performance, and chlorinated hydrocarbon residues in the red-tailed hawk and greated horned owl in south-central Montana. Wilson Bull. 83: 408–418.

Springer, M. A. 1980 Oology: Ultrastructure of eggshells and pesticide analysis of red-tailed hawk eggs. Ohio J. Sci. 80 (In press).